# Farther Out Networking

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Fantastic Data

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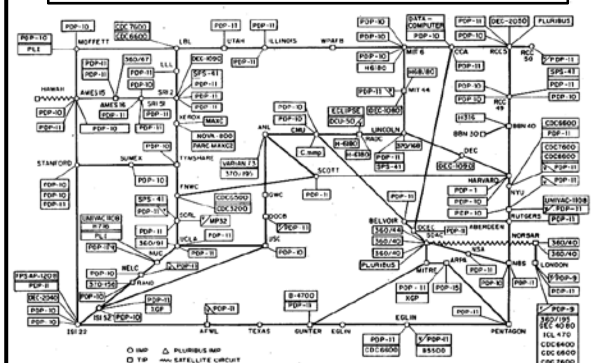
# Diverged Networking Trends

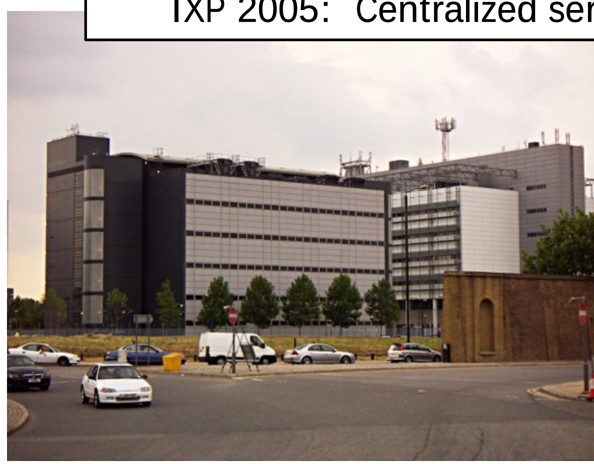
ARPANET 1977

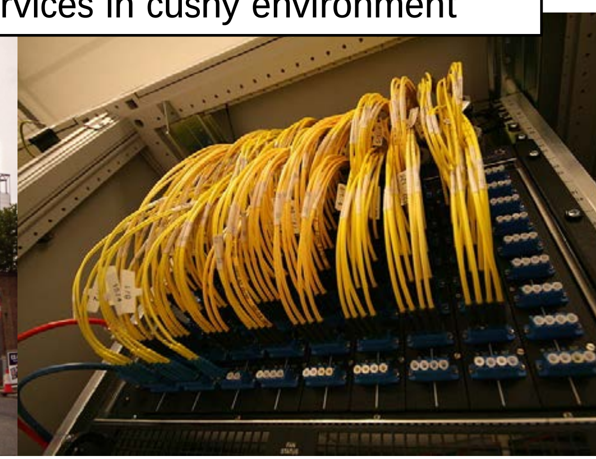


Long distance, node-to-node routes

MANET ENVIRONMENT 2006: Harsh, dynamic environment

IXP 2005: Centralized services in cushy environment





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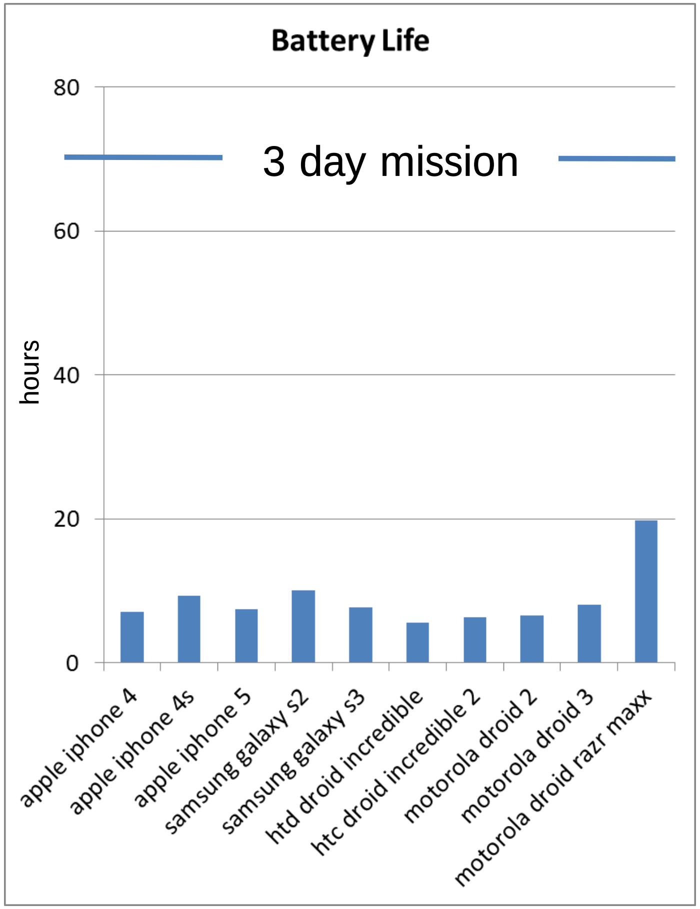
**Internet is centralized and stable. MANET is distributed and dynamic.**

# Other divergence: mobility and battery life

Massive, ubiquitous infrastructure




Data from CNET

Recharge every night

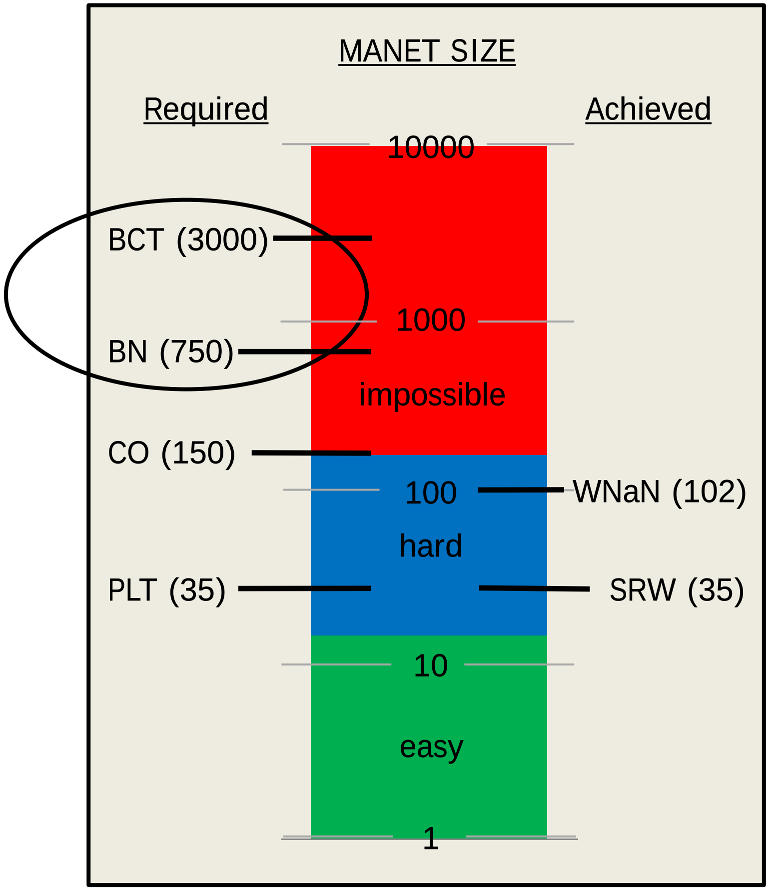
Don’t expect help from the commercial sector.

# MANETs don't fit Internet paradigm

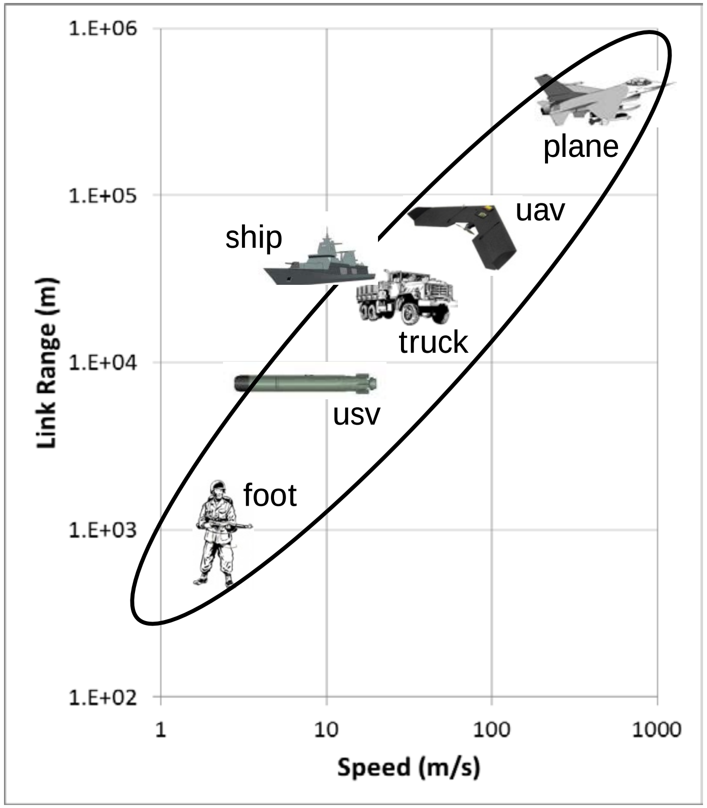
| | IP (commercial) | MANET | Patch/Gap filler |
|---|---|---|---|
| Major issue | Congestion | Interference | |
| Reliability | 100% (wired) | <90% (wireless) | |
| Connectivity | End-to-end | Intermittent | DTN |
| Symmetry | Client-server | Peer to peer | |
| Distribution | 1 to 1,<br>Occasionally 1 to many | Many to many,<br>Occasionally 1 to 1 | Multicast groups |
| Service path | User-ISP | All directions | |
| Stability | High | Low | Stable Backbone |
| Mobility | Fixed Infrastructure | All moving | Mobile Hot Spots, Fixed Wireless |
| Routing | ISP-ISP<br>or<br>ISP-IXP-ISP | Any to any (infrequently)<br>Any to neighbors (mostly) | Deployed router, e.g. MAINGATE.<br>OLSR, AODV, HSLS |
| Geographic Information Correlation | None | High | CBMEN |

**Stop patching. Start fresh.**

# How big? How mobile?




$$\text{mobility} = \frac{\text{platform speed}}{\text{link range}} \approx 0.001 \text{ Hz}$$




**Support largest unit deployed without infrastructure, most mobile platforms.**

# 20 years of failure

We haven’t solved the any-to-any routing problem.

We probably can’t.

But there’s also no reason to believe we have to ...

Let’s solve the real problem.

# Change the approach

Don’t talk about sending packets, instead define Distributed Applications

- What information do warfighters need to share? With whom? When? How frequently?

Create new methods to share this information

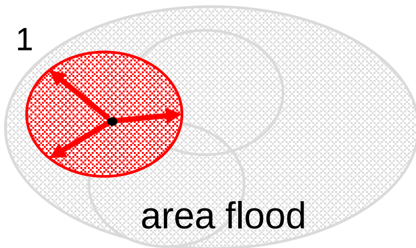
- Different methods for different applications, for different scenarios, etc.

| Application Name | Data Type | Pattern | Comment |
|---|---|---|---|
| Situation Awareness | | | |
| blue force | Database | Area flood | Locally generated/consumed |
| red/neutral force | Database | External/area flood | May be externally generated |
| Coordinated Movement | Database | Area flood | SA + Plan, Opportunity for dynamic filtering |
| Logistics | Database | Area flood | Aggregation operators |
| Video | | | |
| Local Sensor Video (PLT) | 1-way stream | Local directed | Straight forward at small scale |
| Local VTC (PLT) | Multi-way stream | Local directed | Straight forward at small scale |
| Long Distance VTC (CO+) | Multi-way stream | Long distance directed | May be most expensive pattern |
| Maps, Manuals, etc. | Bulk, static data | External access/cache | Convert to ftp/http/tcp/ip at infrastructure |
| General Orders | Database | Global flood | disseminate the easy way |

**Jointly define distributed applications and networking support.**

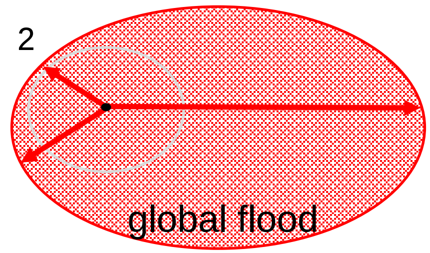
# Information Sharing Patterns

1



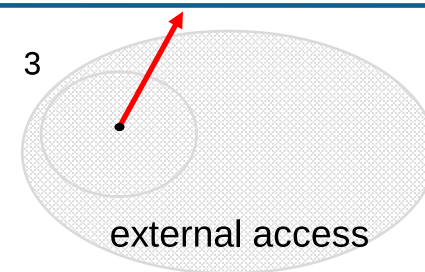

~75% of data load
e.g., situation awareness updates
Lowest cost
Platoon sized overlapping areas
No overhead/no routing burden

2



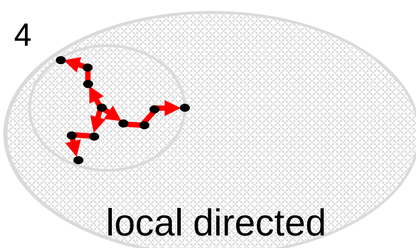

<5% of data load
e.g., general orders
Lower cost
Spread data over brigade sized area
No overhead/no routing burden

3



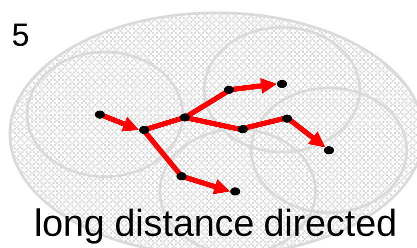

10-20% of data load
e.g., access to external sites—
maps, manuals, large data sets
Infrastructure access
Standard protocols (e.g., tcp/ip)

4



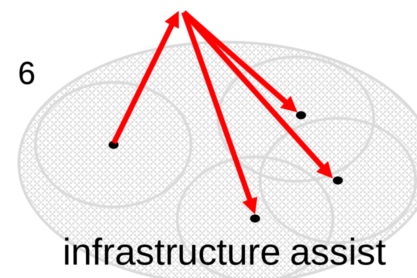

~5% of data load
e.g., local coordination
High cost, moderate setup time
Routing across platoon sized area
Sparse routing table

5




<5% of data load
e.g., long distance coordination
Very high cost, long setup time
Routing across brigade size area
Sparse routing table

6

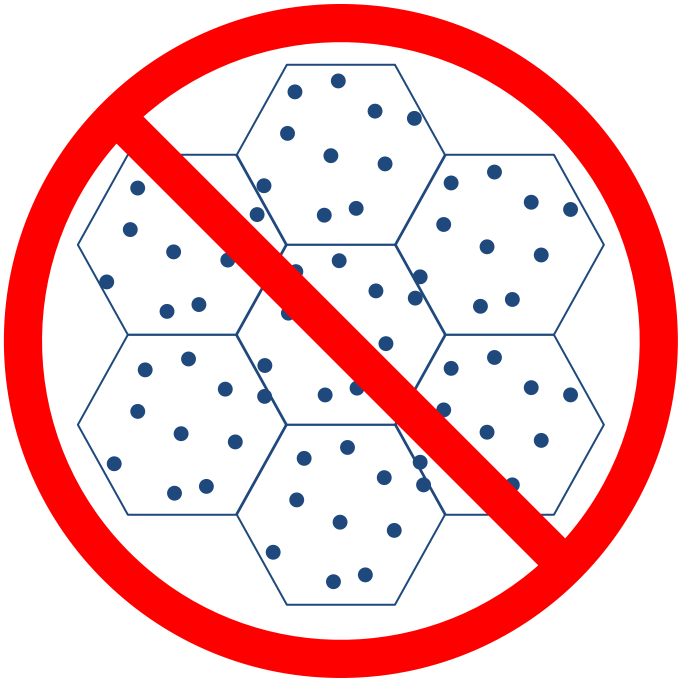



<5% of data load
e.g., long distance coordination
Uses infrastructure to improve
type 5 (long distance directed)
Routing hints from infrastructure

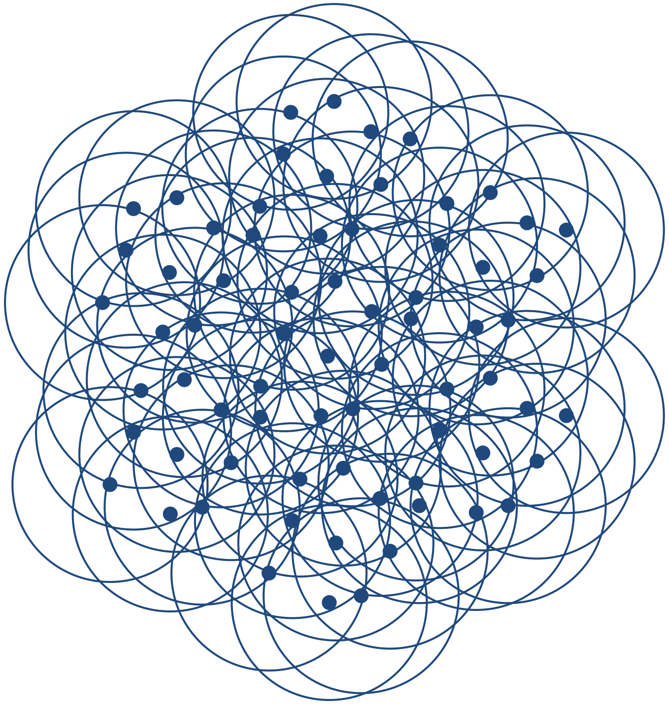
**Chose the correct information sharing pattern for the application.**

# Overlapping neighborhoods yield correct data

<u>Clusters</u>
Many nodes share identical state
Boundaries are network discontinuities
Nodes near boundaries don't get correct data



<u>Overlapping neighborhoods</u>
Highly correlated but not identical state
Continuous, subtle changes across network
Every node gets exactly what it needs



How big is a neighborhood?
Tradeoff knowledge for distribution expense.

**Avoid discontinuities. Employ smooth transitions.**

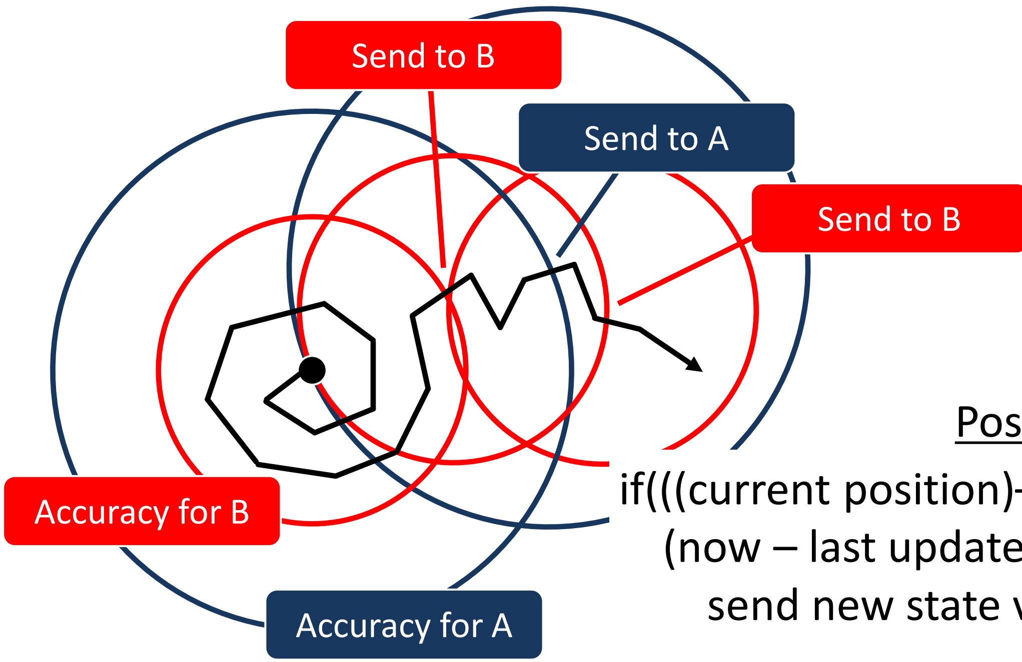
# Computation is our friend

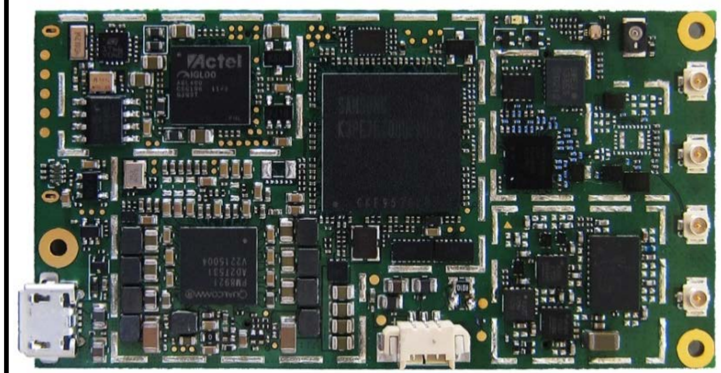
Massive computational power and memory

Limited radio capacity

-> make better transmission decisions

Build the computational logic into the network



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ADAPT module, ~$500
5–20Gflops, 32GB flash (microSD)

For comparison:
SRW 100kb/s-1.8Mb/s
Link-16 31-115Kb/s

<u>Position Reporting Example</u>

if(((current position)–(predicted position))/(maximum error)+
(now – last update time)/(maximum update interval) > 1.0)
send new state vector ($\bar{x}$, $\bar{v}$, $\bar{a}$, t)

**Think more. Talk less.**

# Area Flood

Not your simple flood, no predefined limits

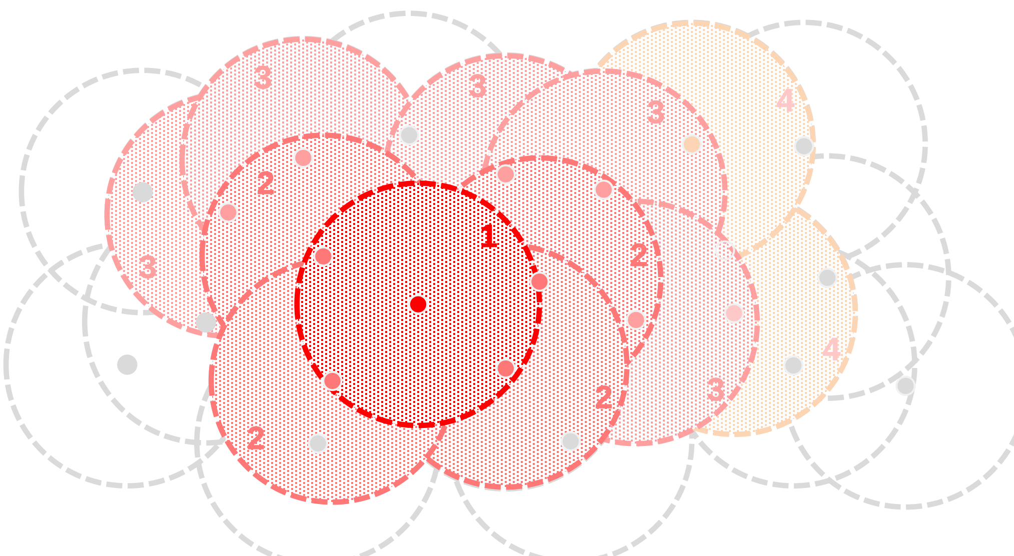
Deliver to neighbors, then reevaluate and

as long as the data is of interest to the next neighbor, keep it moving

Natural disruption tolerance, natural many to many flow

No message addressing, no routing, no global knowledge

Location is a great field for area flood filtering, what about other data fields?



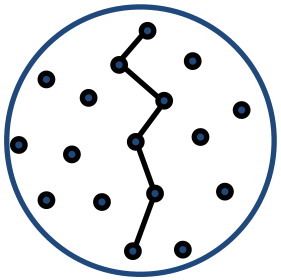

“area flood” and “overlapping neighborhoods” yield efficient data sharing.

# Directed Patterns

“Local directed” is straightforward and easy

In a small neighborhood, pretty much anything works

Most of the work is done by tracking neighbors and neighbors of neighbors



“Long distance directed” is hard, but infrequent

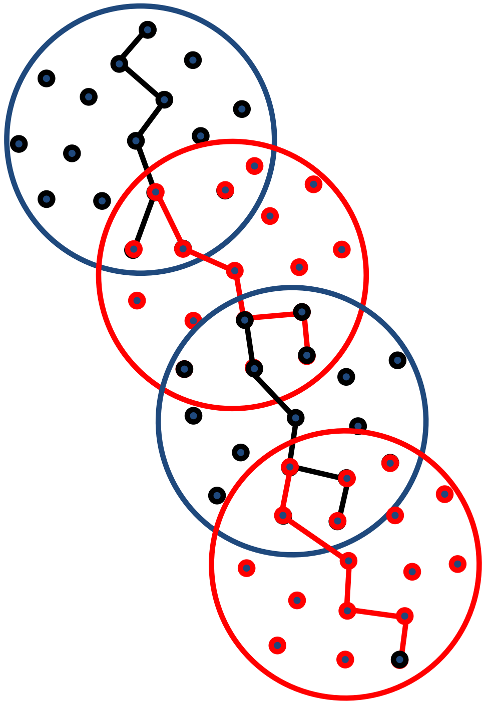
How many long distance routes are actually required in a military operation?

How much time do we have to set them up?

Minimize its use by using other patterns

Don’t try for optimal routes

Start with a general idea that the other node is sort of over there and refine the route as it moves through neighborhoods closer to the destination



Routing should not be the networking primitive.

# Prototype system development

Novel algorithms

and

Working implementations

Make it cool. Make it work.

# Data generation for emulation and test

Protocols are likely to be data centric

- Generating appropriate data is a large, unsolved problem area
- Opaque packet load is not the right approach
- How are we going to do it?

Data types

- How rich is the data set?
- How many types? Which types?
- How many instances of each?

Is data generation correlated?

- With movement?
- With other data sources: Do 10 soldiers suddenly report the same observation?

There are some existing real data sets

- Access is a problem
- Are they even appropriate if we change the problem statement?

**Generate a lot of high quality data to test protocols.**

# Theory Questions

Challenge/verify the assumptions

- e.g., all of the numbers in this presentation

Explain protocol success/failure

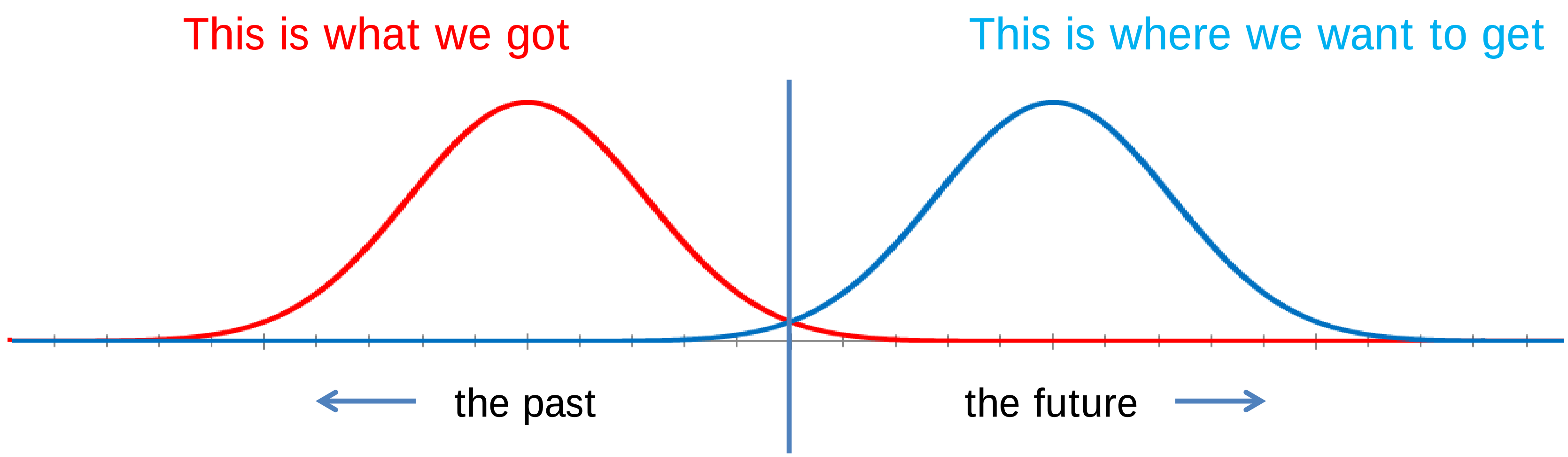
- Why does it work/not work?
- What are the hidden dependencies?
- Where else is it likely to work/not work?

Study fundamental limits

- When we change the approach, how do these limits change?

**Theory tasks to support protocol development.**

# Working Group Goals



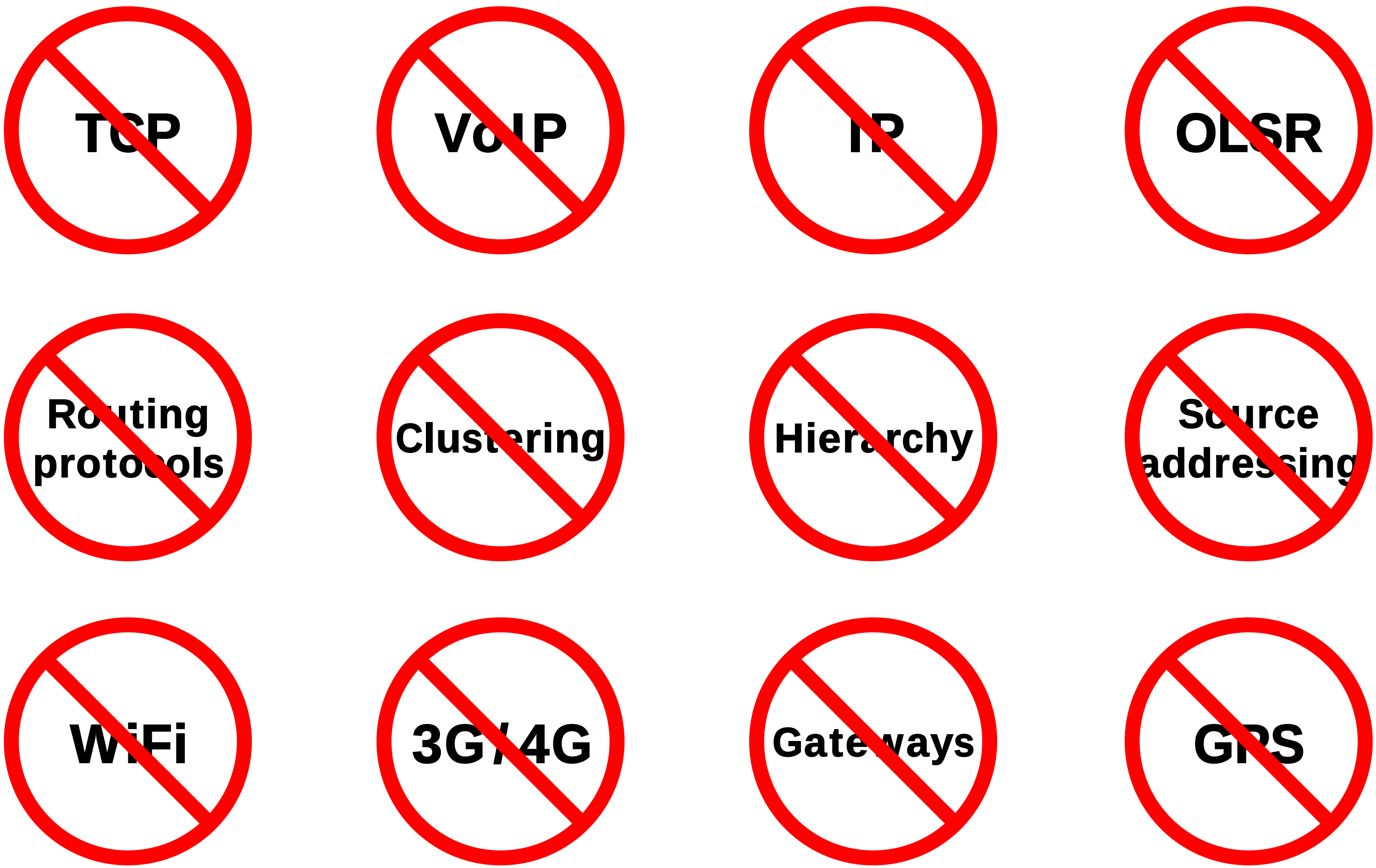

Which network problems are important?

Which approaches might lead to a breakthrough?

How are we going to show that the new approaches work?

**Why should the government invest more money in MANET technology?**

# Look farther out




Start a networking revolution.